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MATERIALS AND TECHNIQUES FOR SCALING LASERS TO HIGH POWER

Many applications require that lasers operate at power levels of >100 Watts to perform activities such as materials-processing. In order to achieve this power level, special care must be taken to appropriately manage the thermal gradients present in the gain medium. There are many ways this can be accomplished, depending on the gain medium selected and the architecture of the laser. First, it is generally advantageous to pump the laser material with laser diode arrays to minimize the heat introduced into the crystal. For the case of Yb:YAG laser, or ytterbium-doped  $\text{Y}_3\text{Al}_5\text{O}_{12}$ , the pump and laser wavelengths are quite close (943 versus 1030 nm), offering the advantage of generating minimal waste heat (8% of the pump power). Our Yb:YAG laser, which has produced 131 Watts thus far, also relies on the use of "end-caps" or undoped pieces of YAG to shift the point of maximum stress from the surface of the laser rod, rendering it to be internal to the rod. A similar geometry was applied to the design of a 2010 nm Tm:YAG laser, although in this case we found that about 70 % of the pump light is converted into heat. Use of a short resonator assures that the laser is optically stable, although the beam quality faces significant degradation ( $M^2=20$ ).

It appears that the YAG crystal is particularly well-suited to surviving high thermal gradients without fracture, by virtue of its large conductivity and other favorable parameters. We have recently discovered a new laser crystal based on the ZnSe host that offers a similar level of thermal robustness as YAG, but where divalent chromium serves as the laser ion. The ZnSe:Cr<sup>2+</sup> gain medium is tunable in the 2200-3000 nm region and we are presently working on the first diode-pumped laser module of this type, employing 1700 nm laser diode pump arrays.

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